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# EVALUATION OF WHEELCHAIR LOADERS FOR PERSONAL VEHICLES

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The contents of this report reflect the views of the authors and not necessarily the official view or opinions of the Transportation Development Centre of Transport Canada.

Un sommaire en français de ce rapport est inclus avant la Table des matières.

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17. Abstract

This report presents the results of an evaluation of five devices to load wheelchairs into personal vehicles. Six disabled consumers and two able bodied family members were recruited for the study. The ease of operation of each loader was rated by trained observers. Storage and parking space requirements, passenger requirements, driver needs and other lifestyle issues were evaluated by questionnaire. The advantages and disadvantages of each loader are reported. The appropriateness of the loaders for users with different abilities and needs is assessed. Three were found to have design difficulties. Suggestions for improvements to these devices are offered.

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17. Résumé

Le présent rapport concerne l'évaluation de cinq dispositifs de chargement de fauteuils roulants à bord de voitures de tourisme, à laquelle ont participé six personnes handicapées et deux accompagnateurs non handicapés. La commodité de chacun des dispositifs a été évaluée par des observateurs qualifiés. Un sondage par questionnaire a été fait sur les espaces de rangement et de stationnement nécessaires, sur les besoins du conducteur et des passagers et sur divers thèmes relatifs au style de vie de chacun. Les avantages et les inconvénients de chaque dispositif ont été signalés. L'utilité de chaque dispositif a été établie en fonction des handicaps décrits et des besoins à satisfaire. Trois d'entre eux nécessitent certaines modifications pour lesquelles des suggestions sont proposées.

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# SUMMARY

Disabled and elderly persons use wheelchairs and scooters to increase their mobility. When they want to travel further than the short distances allowed by these methods, they often need to transport their mobility aid in a personal automobile. A common limitation to the use of automobiles is the inability to load the wheelchair or scooter into the vehicle. The characteristics of available mechanical devices to load wheelchairs and scooters are not widely known. This paper reports the results of a study to evaluate five loading devices: a back seat extension loader, a cartop carrier, a rear bumper chair carrier, a manual trunk loader and a trunk crane lifter for an electric scooter.

Eight consumers were recruited to represent a wide range of disabled persons and their family helpers. Body dimensions, strength and characteristics of disability were measured to describe these volunteers. Subjects tested each of the loading devices that they were able to operate while researcher-observers rated their performance. Measurements included the forces required to operate the devices and the space needed for parking. Loss of cargo space, loss of passenger space and the time taken to operate each device are discussed.

The back seat extension loader was suitable for a person who could transfer independently and perform simple manual tasks. It was well designed, was easy and quick to use and could be operated within the space of a two door vehicle with one door wide open. The device cannot be fitted into small automobiles or vehicles with four doors. Passenger space in the rear seat must be relinquished with this device.

The cartop carrier could be used by someone who could transfer independently and use a simple rocker switch. It was fast and easy to use. It could be used on almost any vehicle and required no sacrifice in cargo or passenger space. The height of the vehicle and loader could be accommodated in most underground garages.

The user of the rear bumper carrier had to be able to walk short distances and have good upper limb function. The device was inexpensive and requires little extra parking space. Operation of the loader required a length of time which was considered to be inconvenient by the disabled consumers. Subjects had considerable difficulty exerting the 92 Newton force required to disengage a pin. It has been recommended that this pin be redesigned. Consumers also complained that this product was difficult to use without becoming covered with road dirt.

The manual trunk loader was difficult to use, requiring a force greater than that needed to lift the wheelchair vertically from the ground without the lifter. A complete redesign of this device was recommended.

The crane lifter for the electric scooter required the manual removal

of the scooter seat. This operation required a force which exceeded that required to lift a manual wheelchair. The entire loading procedure was considered by the consumers to require an excessive amount of time. The use of the trunk for cargo must be given up. The redesign of the scooter seat attachment or reduction of weight of the seat has been recommended to facilitate the manual transfer of this component. Alternatively, a suitable attachment must be designed so that the crane can be used to lift the seat.

Suitability of each loader for users with different abilities and needs was assessed. Suggestions for design improvements to three of the loaders are presented.

A proposal for the preparation of a guide to wheelchair loading methods and special equipment is included. The tasks required to complete the collection of the required information are listed.

## SOMMAIRE

Les personnes âgées et les handicapés peuvent surmonter leur mobilité réduite grâce aux fauteuils roulants classiques ou de type scooter. Mais, lorsqu'ils désirent aller plus loin que ne l'autorisent ces appareils, il leur faut nécessairement les charger à bord d'une voiture de tourisme. Tâche difficile, sinon impossible, d'autant que les intéressés ne connaissent pas toujours les aides mécaniques qui pourraient leur permettre de contourner cette difficulté. Le présent rapport rend compte de l'évaluation faite sur cinq dispositifs de chargement, à savoir: chargeur sur siège arrière, chargeur sur pavillon, chargeur sur pare-choc arrière, chargeur manuel de coffre arrière et chargeur de coffre à grue dans le cas des scooters.

Pour les essais, il a été fait appel à huit volontaires formant un groupe représentatif de la population handicapée et des parents accompagnateurs. Leurs dimensions, leur capacité d'effort et la nature du handicap de chacun ont été au préalable mesurées. Chacun d'eux a fait fonctionner les dispositifs comme il le pouvait, sous l'oeil des chercheurs-observateurs qui prenaient des notes sur la somme des efforts nécessaires, la perte d'espace utile, le temps pris pour effectuer les manoeuvres et les surplus d'espace nécessaire au stationnement.

Le chargement sur le siège arrière convient lorsque l'utilisateur est capable de transférer par ses propres moyens et d'effectuer des tâches manuelles simples. Ce dispositif, bien conçu et d'emploi facile et rapide, requiert juste l'espace offert dans une voiture type coach lorsque la portière est ouverte; il ne convient cependant pas aux petites voitures ni aux voitures type berline. Il occupe tout l'espace libre à l'arrière.

Le chargement sur pavillon peut convenir à la personne capable de transférer seule et de manipuler un interrupteur à bascule. Ce dispositif a été jugé rapide et facile d'emploi, adaptable à presque tous les types de véhicules, tout en laissant libre l'espace à l'arrière ou dans le coffre. Enfin, la hauteur totale du véhicule et de son chargement est inférieure à la hauteur libre à l'entrée de presque tous les garages souterrains.

Le chargement sur le pare-choc arrière convient à la personne qui peut marcher de courtes distances et dont la motricité des membres supérieurs est bonne. En plus d'être bon marché, ce dispositif est peu encombrant. Le temps pris pour la manoeuvre a cependant constitué un inconvénient. Les volontaires ont considéré comme pénible la force de 92 newtons qu'il fallait exercer pour déloger une cheville; cet élément devra donc être réétudié. De plus, ils se sont plaints qu'ils ne pouvaient éviter de se salir en utilisant ce dispositif.

Le chargeur de coffre arrière à manoeuvre manuelle a exigé un effort musculaire supérieur à celui requis pour soulever le fauteuil sans aide aucune. La réétude de fond en comble du dispositif est donc recommandée.

Le levage du scooter avec la grue nécessite le démontage préalable du siège, ce qui exige un effort musculaire supérieur à celui requis pour soulever un fauteuil non électrique. Le temps de manoeuvre a été jugé excessif. Ce type de dispositif devra donc être écarté. Pour rendre le levage du scooter plus aisé, il faudra trouver un mode de fixation plus simple du siège ou alléger celui-ci, ou bien alors trouver le moyen de soulever le scooter au complet avec la grue.

Le rapport établit ensuite l'utilité de chaque dispositif en fonction des handicaps décrits et des besoins à satisfaire et suggère les modifications à apporter à trois d'entre eux.

Enfin, il propose la publication d'un guide sur les techniques de chargement et sur le matériel correspondant et énumère les tâches à accomplir afin de recueillir l'information nécessaire.

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# 1. INTRODUCTION

A Canadian workshop committee of health care professionals, disabled consumers and a private sector vehicle equipment installer (5) was convened with the support of the Transportation Development Centre, Transport Canada, to discuss the problems and needs of disabled and elderly persons regarding loading their wheelchairs into personal vehicles. It was determined that, although many devices to load wheelchairs and electric scooters were available, little was known about their use. The committee recommended to the Transportation Development Centre that studies be undertaken to gather information required to produce a guide for the selection of loading devices. This report presents the results of a preliminary study to establish the physical requirements of users and the impact these devices would have on their lifestyles. This material will form the basis of a proposed wheelchair loader selection guide for consumer use. Additional information regarding Canadian sources of equipment, installers, service and funding resources will have to be gathered for inclusion in the selection guide.

## 2. METHOD

### 2.1 Selection of Loaders

This study was limited to loaders which were designed to lift or facilitate manual lifting of a manual wheelchair or an electric scooter without an occupant. Five loaders were selected, each one representing a generic type of apparatus. These devices were designed to meet the needs of disabled and elderly people with a wide range of functional ability levels.

### 2.2 Selection of Subjects

Eight subjects were selected to represent a wide range of functional ability levels, ages and lifestyles. Standard anthropometric measurements, grip strength, pinch strength and standard neurological and physical tests were performed to describe the subjects (1, 2, 4).

### 2.3 Test Procedure

The operation of each loader was broken down into sequential steps. Subjects who were able to operate each device were asked to perform each step while being assessed by a team of trained observers. Ease of use was rated as "with ease", "with difficulty" or "not possible" for each subject on the basis of observation and subject's comment.

Parking space requirements and cargo displacement were measured. Subjects were asked a questionnaire to determine how each loader would impact on their lifestyle. They were asked questions about cargo requirements, passenger requirements, use of the vehicle by other drivers, parking requirements and the implications of time taken to operate each device.

Selected forces required to operate the loaders were measured using an instrument specially designed to measure push/pull forces. It consisted of a load cell with rods to transmit the forces during pushing and a line to transfer pulling forces. Both mechanisms had features which ensured that the measurements were taken along the measurement axis of the load cell.

## 3. SUBJECTS

Subjects represented a wide range of lifestyles, disabilities and ages. Table 1 summarizes the subject characteristics.

Table 1 Subject Characteristics

| Characteristic | Subject 1 | Subject 2 | Subject 3 | Subject 4 | Subject 5 | Subject 6 | Subject 7 | Subject 8 |
|---|---|---|---|---|---|---|---|---|
| Sex | female | female | female | female | male | male | male | female |
| Age | 54 | 22 | mom-42<br>son-15 | wife-73<br>spouse-74 | 36 | 21 | 40 | 59 |
| User of wheelchair or scooter | self | self | son | husband | self | self | self | self |
| Medical condition | both legs amputated cardiac disease | Charcot Marie Tooth Dis. (degenerative neuro-muscular disorder) | Mom-healthy son-spina bifida | wife-healthy spouse-stroke, hemiparesis | paraplegia plus some upper limb deficit | paraplegia | cerebral palsy | poliomyelitis |
| Wheelchair/scooter | lightweight manual | electric scooter | Quickie sports chair | lightweight manual | lightweight manual | Quickie sports | ltwt manual + scooter | lightweight manual |
| Lifestyle | homemaker-one child + husband + boarder at home | student, part time job, active socially, lives alone | son attends highschool, mom-home (with one other child) spouse works | husband & wife retired | professional office work, | student, part time job lives alone | appliance sales, shares home with family | retired, lives alone, limited social life |
| Frequency of travel with chair/scooter | frequent, household shopping + banking etc. | daily | daily | infrequent mostly social | frequent, | frequent | frequent | infrequent |
| Present Method of Loading chair/scooter | third party assistance | crane loader | manual | third party assistance | manual | manual | manual sometimes third party assistance | rear seat extension arm |
| Weight | 57 | 45 | 65 | 59 | 72 | 52 | 84 | 61 |
| Dominance | R | Ambidextrous | R | R | R | R | R | R |
| Grip Strength | | | | | | | | |
| R | 21 | 21 | 30* | 23 | 0.5 | 44 | 23 | 10 |
| L | 14 | 25* | 26* | 21 | 5 | 40 | 3 | 0 |
| Pinch Strength | | | | | | | | |
| R | 4 | 1 | 6* | 5 | 0.3 | 10* | 1 | 0 |
| L | 2 | 4 | 7* | 4 | 2.3 | 9* | 0 | 0 |

Table 1 (continued)

| Characteristic | Subject 1 | Subject 2 | Subject 3 | Subject 4 | Subject 5 | Subject 6 | Subject 7 | Subject 8 |
|---|---|---|---|---|---|---|---|---|
| Spasticity | | | | | | | | |
| upper limbs | N | N | N | N | N | N | Y | N |
| lower limbs | N | N | N | N | Y | Y | Y | N |
| trunk | N | N | N | N | Y | Y | Y | N |
| Sitting Balance | I | I | I | I | I | I | I | I |
| Ability to Transfer | I | I | I | I | I | I | I | I |
| Walking ability | Short distance | Short distance | Average Able/bodied | Average Elderly | None | None | None | 3 paces |
| Sensory Deficit | | | | | | | | |
| upper limb | N | N | N | N | Y | N | N | N |
| Motor Deficit | | | | | | | | |
| upper limb | N | N | N | N | Y | N | Y | Y |
| Passive Range of Motion Deficit | | | | | | | | |
| upper limb | N | N | N | N | N | N | Y | N |
| eye height | 76 | 72 | 76 | 71 | 73 | 67 | 77 | 67 |
| sitting height | 86 | 80 | 86 | 83 | 83 | 82 | 89 | 79 |
| leg length | 56 | 51 | 51 | 50 | 64 | 65 | 51 | 50 |
| buttock-knee length | 58 | 56 | 58 | 57 | 61 | 47 | 69 | 61 |
| arm length | 76 | 73 | 71 | 75 | 79 | 84 | 79 | 72 |
| active reach forward | 130 | 130 | 142 | 139 | 105 | 122 | 114 | 130 |

LEGEND

Units time-years weight-kilograms length-centimeters

L= Left Y= Yes D=Dependent

R= Right N= No I=Independent

* Indicates that this score is above the average for that sex (3).

Grip strength: average male R=47.3 kg L=42.6 kg average female R=29.0 kg L=24.5 kg

Pinch strength: average male R= 7.7 kg L= 7.5 kg average female R= 5.1 kg L= 4.9 kg

## 4. BACK SEAT EXTENSION LOADER

### 4.1 Description and Operation

The back seat extension loader selected for this study was the Anthony Insider manufactured by Independent Living Aids. This device is a track and crane system. The track is mounted with five screws to the floor of a two door mid-sized to full-sized automobile. A motor, wired to use the power from the vehicle's 12 volt battery, drives an articulated arm along the track to load and unload the chair. Two rocker switches actuated the movement of the articulated arm in, out, up and down. The loader was designed to accommodate a folded wheelchair, which does not exceed the following dimensions: height 94 cm, seat depth 46 cm and width 30 cm.

The device used in this test was mounted to load from the passenger's side of the vehicle, although it could have been mounted to load from the driver's side. The driver unlocked the front door and transferred into the front seat of the vehicle. The footrests of the wheelchair were removed and stowed in the car. The wheelchair was folded manually and placed in a position beside and facing the rear seat. The extension arm was moved out of the car (figure 1) to its full limit of travel while the driver carefully guided it underneath the folded chair seat (figure 2). Pushing the up switch brought the chair off the ground (figure 3) and it continued to elevate until it was above the outer rim of the entry port. The extension arm, holding the wheelchair, was moved in along the track while the user guided the castor wheels (figure 4). Once inside, the wheelchair was lowered to its resting position (figure 5). The driver then pulled her legs into the car, closed the passenger door and slid sideways to her proper position in the driver's seat. Unloading the chair required the same steps in reverse order.

### 4.2 Observations

Subjects 1, 2 an 8 participated in the evaluation. All three subjects were able to load and unload a standard manual wheelchair with ease. When the wheelchair was moving out of the entry/exit port it was necessary to gently guide the wheels of the chair to avoid collision with the back of the front seat. While the chair was moving into the vehicle it was necessary to ensure that the castor wheels were aligned with the track to prevent them from jamming at the entry port.

### 4.3 Advantages

1. Ease of Use.
   The functional requirements to operate this device are minimal. A person must be able to transfer independently, manually fold the wheelchair while sitting on a car seat, operate a simple rocker switch, do simple manipulations to guide the device and chair and transfer from the passenger's seat to the driver's seat.

2. Speed of Operation

   The user sits with most of her body inside the vehicle protected from bad weather for the 1 1/2 minutes required to load the chair.

3. Parking requirements

   The loading of the chair requires 85 cm extra room at the side of the vehicle. This is less than the extra space (109 cm) required to fully open the side door of the mid-sized car used in the test.

### 4.4 Disadvantages

1. Vehicle requirements

   The device cannot be mounted in small cars or vehicles with four doors.

2. Cost.

   This device cost approximately $3000. installed.

3. Cargo and Passenger Space

   The use of the rear seat by passengers is lost because the loader is installed along the entire length of the floor in front of the rear seat. It is still possible to use the seat (or the space it occupied, if it is removed) for cargo.

### 4.5 Recommendations

The back seat extension arm loader is suitable for a person who can transfer independently and perform simple manual tasks. The individual should have few passenger requirements and the financial means to purchase a mid-sized or larger car and to install the loader. Examples of the type of person are:

1. an elderly person who carries no more than one spouse or friend;
2. a professional person who uses the vehicle for travelling to and from work (perhaps as a second family car);
3. a student or young person who does not need extra passenger space
4. a single parent with a single disabled child and
5. a parent who has two cars in the family one of which could be used only for transporting one passenger.

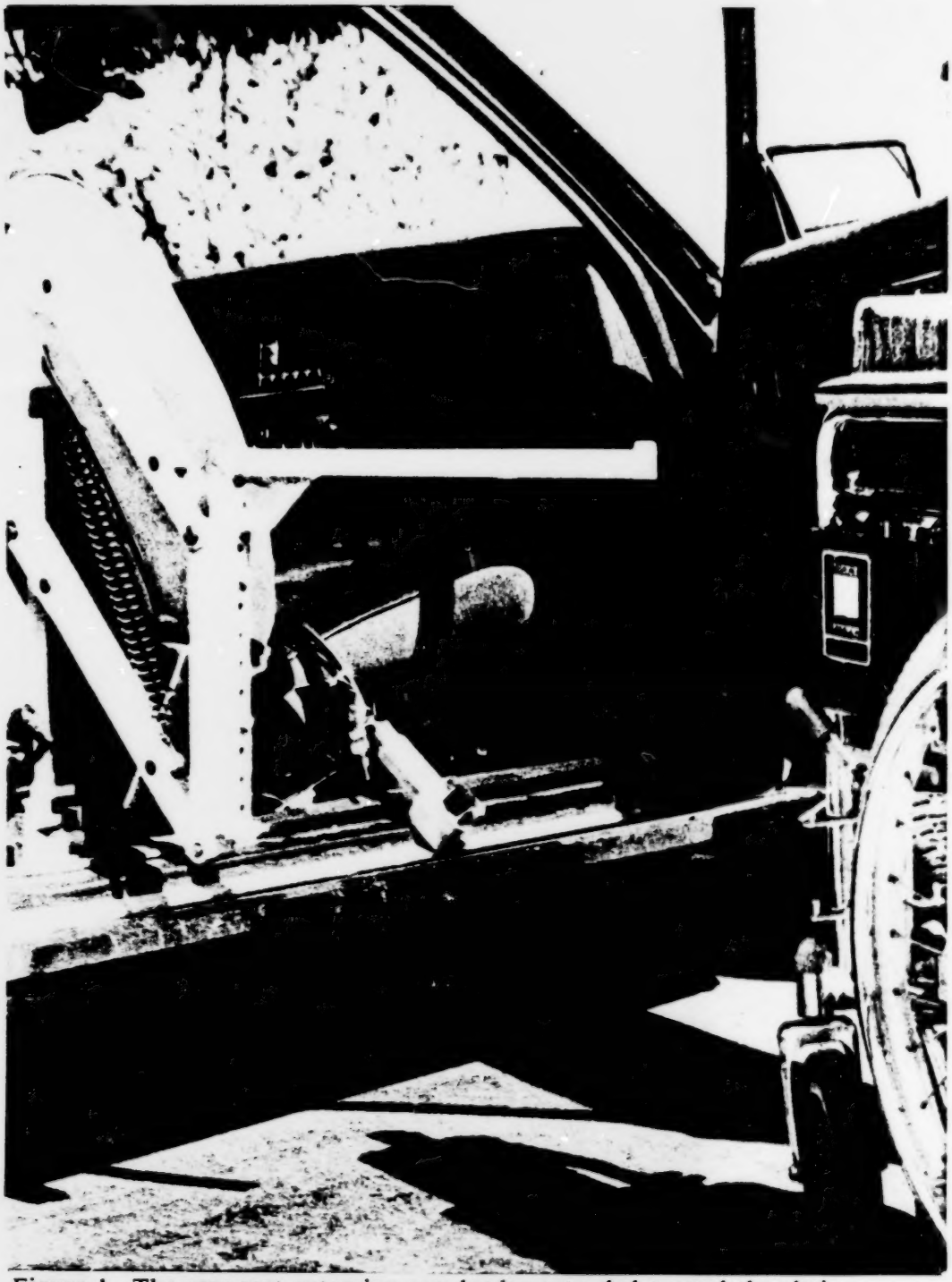

Figure 1. The rear seat extension arm loader extended toward the chair

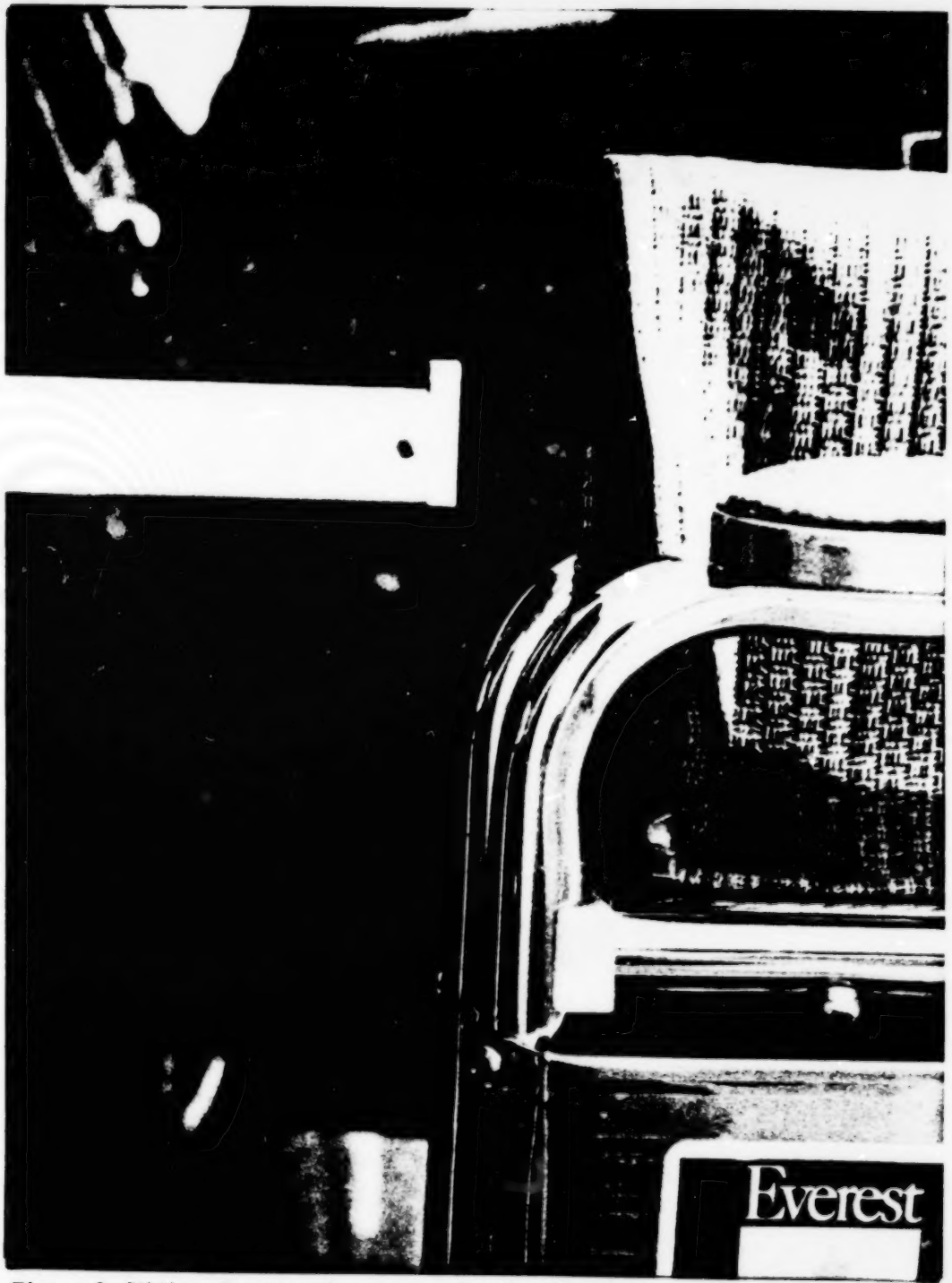


Figure 2 Sliding the extension arm under the folded seat

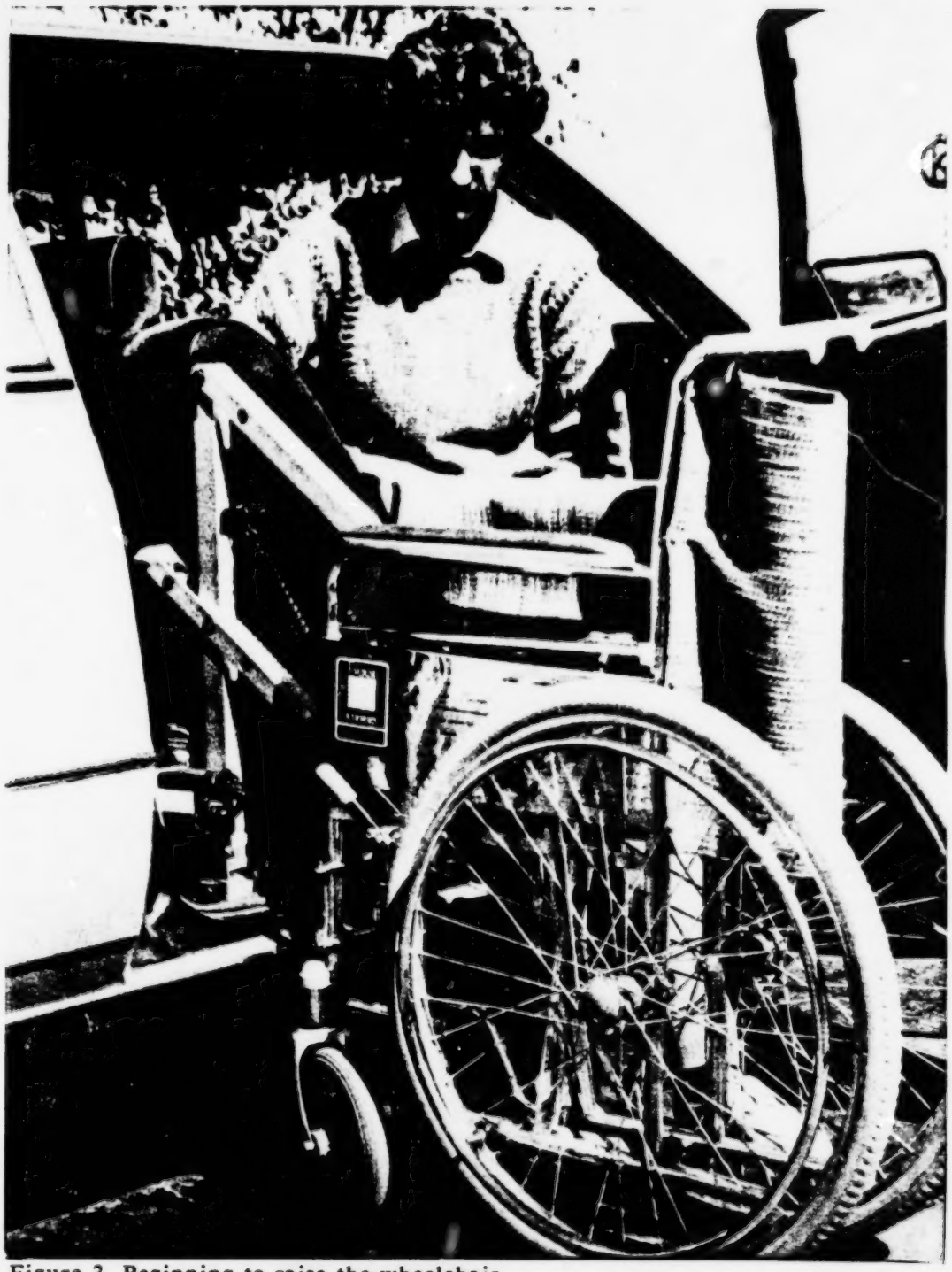

Figure 3 Beginning to raise the wheelchair

Figure 4 Guiding the castor wheels as the chair moves into the vehicle

Figure 5 Moving the wheelchair into the car

## 5. CARTOP CARRIER

### 5.1 Description and Operation

The loader representing this type of device was the Braun Chair Topper manufactured by the Braun Corporation. The mechanism was encased in a fiberglass box which was attached through the roof of the automobile with rivets (figure 6). The dimensions of the closed box were 56 cm high (including attachment posts), 136 cm long and 127 cm wide. Power for the device was obtained from the vehicle's 12 volt battery. A toggle switch, mounted inside the car, actuated all the functions of the loader. The driver transferred to the front seat of the vehicle. The fiberglass case was opened and the lifting mechanism lowered (figure 7). The arm of the device was placed under the seat of the wheelchair. When the loader raised the wheelchair from the ground the chair automatically folded (figure 8 and 9). After the loader placed the chair inside the fiberglass case (figure 10) the case was closed. Unloading was simply the reversed procedure.

### 5.2 Observations

Subjects 1 to 7 inclusive tested the loader and found no difficulties with normal operations. The time taken to load the wheelchair ranged from 55 to 90 seconds. Unloading required between 46 and 86 seconds. One person objected to the use of attachments through the roof of the automobile and one subject questioned whether the chair would swing to hit the car on a windy day. Wind resistance during travel was a concern of one subject. A student complained that the device would be too expensive (at approximately $3500.) for him. Others felt that the Chair Topper would be affordable if they had to choose between this and using a van with a platform lift. During the testing, on one occasion, the lifting mechanism travelled beyond its end stop and had to be repaired.

### 5.3 Advantages

1. Ease of Use
   The ability to transfer independently from the wheelchair and to use a simple rocker switch is all that is required to operate the device.
2. Speed of operation
   The device works quickly (less than 100 seconds to load or unload) and its design allows the operator to be protected from weather during its operation.
3. Vehicle requirements
   Most vehicles would be compatible with this loader.
4. Cargo and Passenger Space
   No cargo or passenger space in the vehicle is given up.
5. Parking Requirements
   The 193 cm. height of the vehicle plus loader could be accommodated in most underground garages.

5.4 Disadvantages

1. Cost
   The price was approximately $3500. installed.

5.5 Recommendations

The car top carrier is suitable for a person who can transfer independently and use a simple rocker switch. The device would be especially valuable for:

1. an elderly couple or individual who travel(s) frequently;
2. a homemaker who uses a car and wheelchair for general household shopping;
3. a person who had limited or no use of his legs and had difficulty pulling the chair into car and
4. a parent who has difficulty lifting the chair of a child.

Figure 6 Transferring to the driver's seat

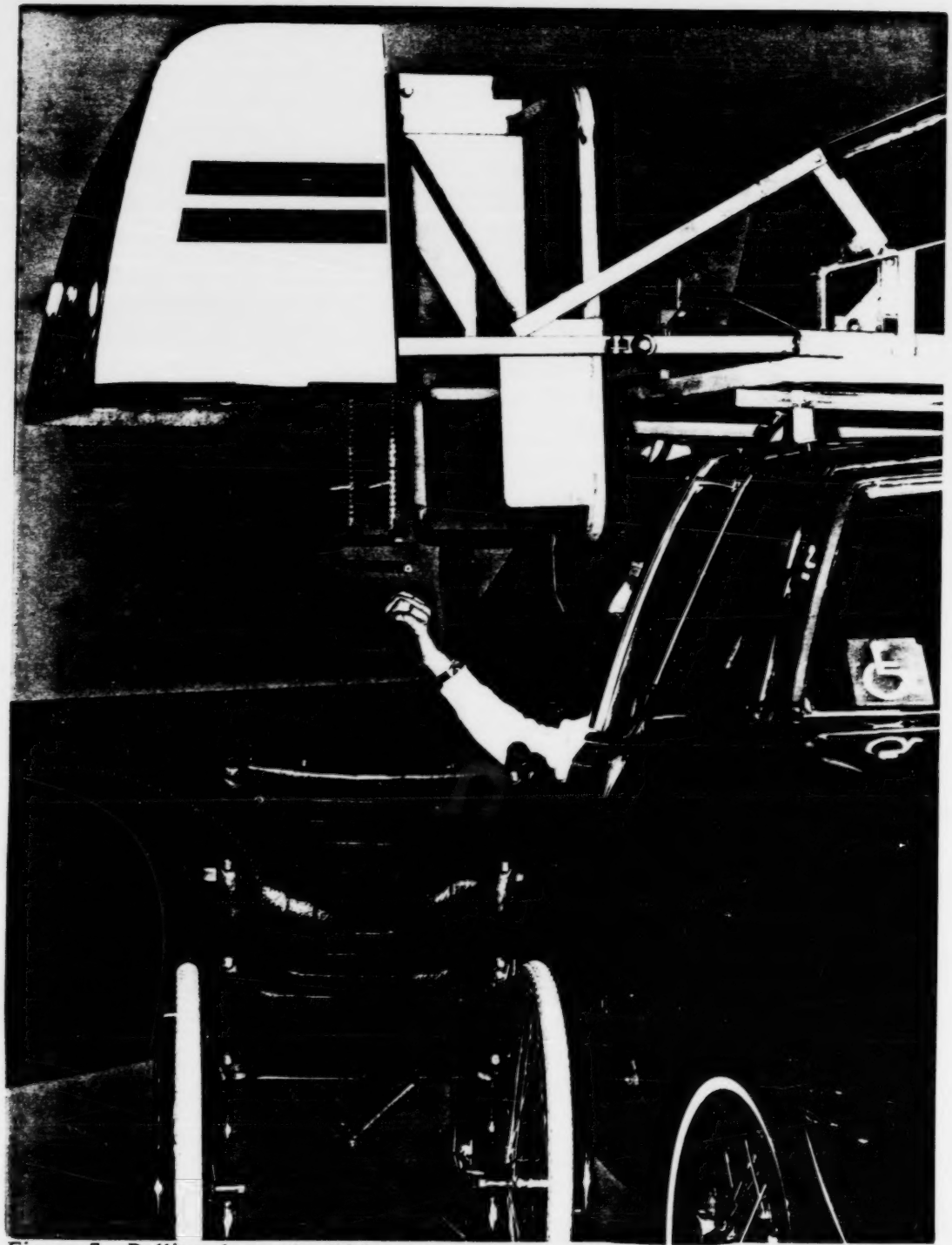

Figure 7 Pulling down the lifting mechanism

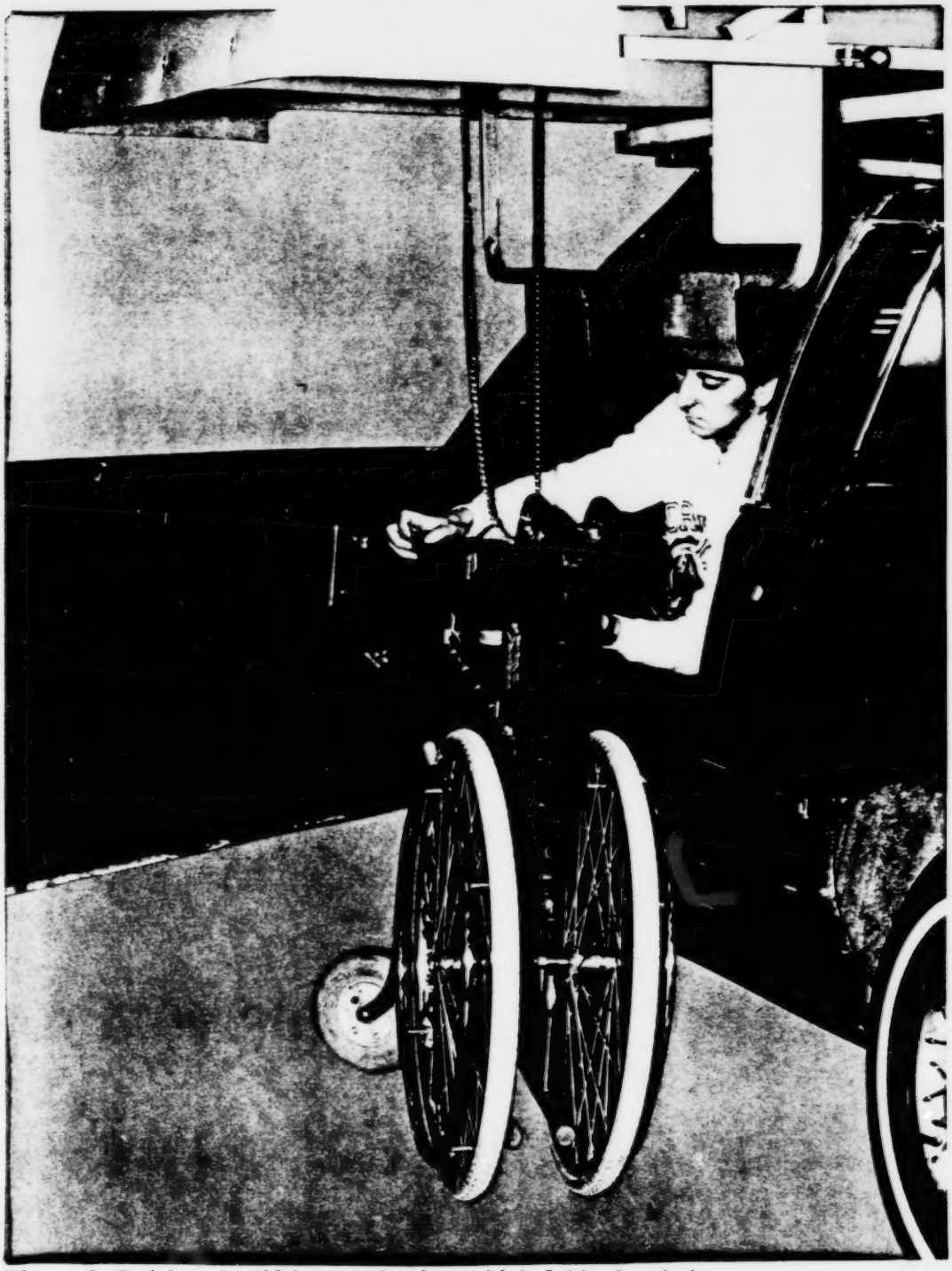

Figure 8 Raising the lifting mechanism which folds the chair

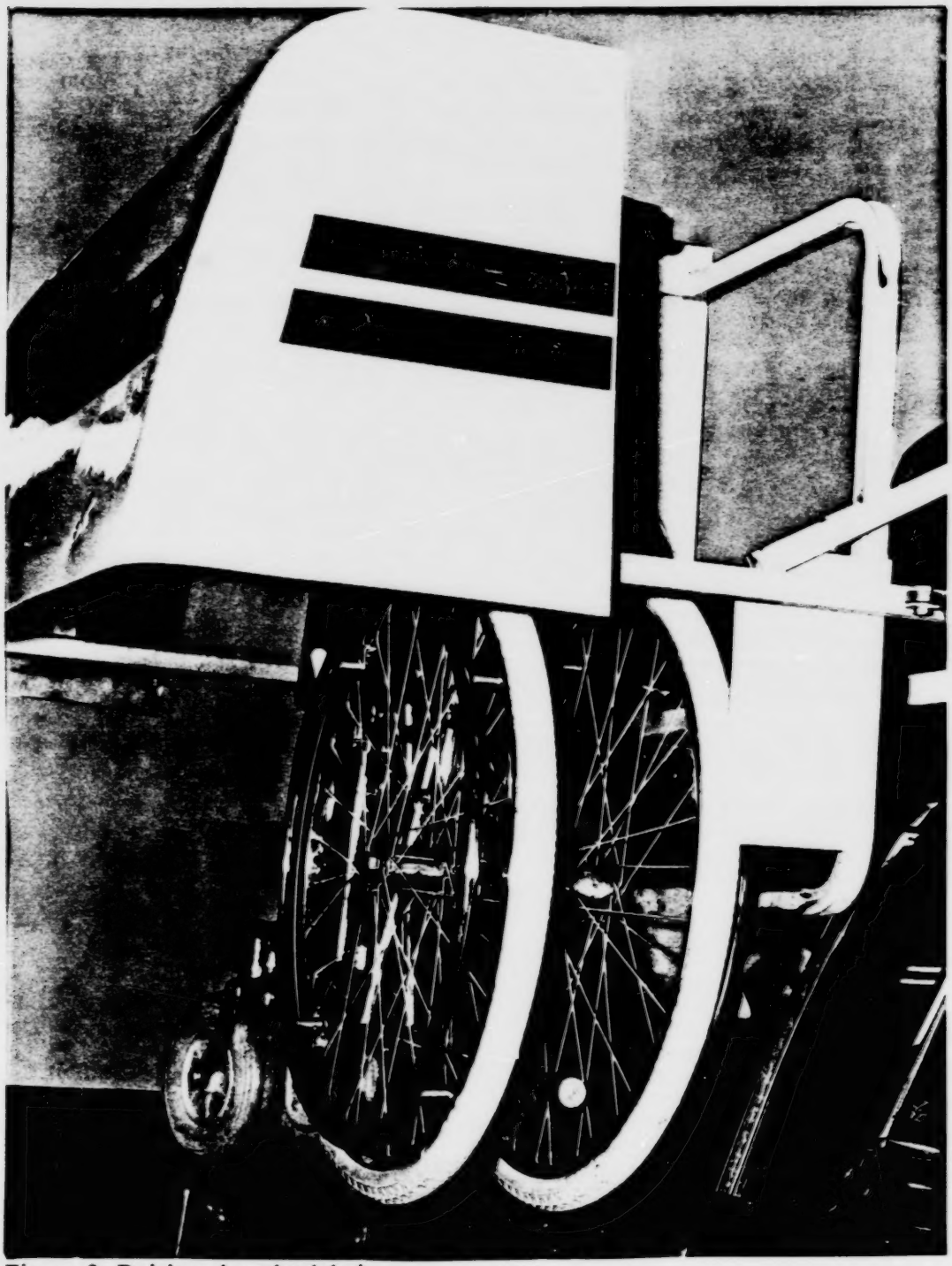

Figure 9 Raising the wheelchair

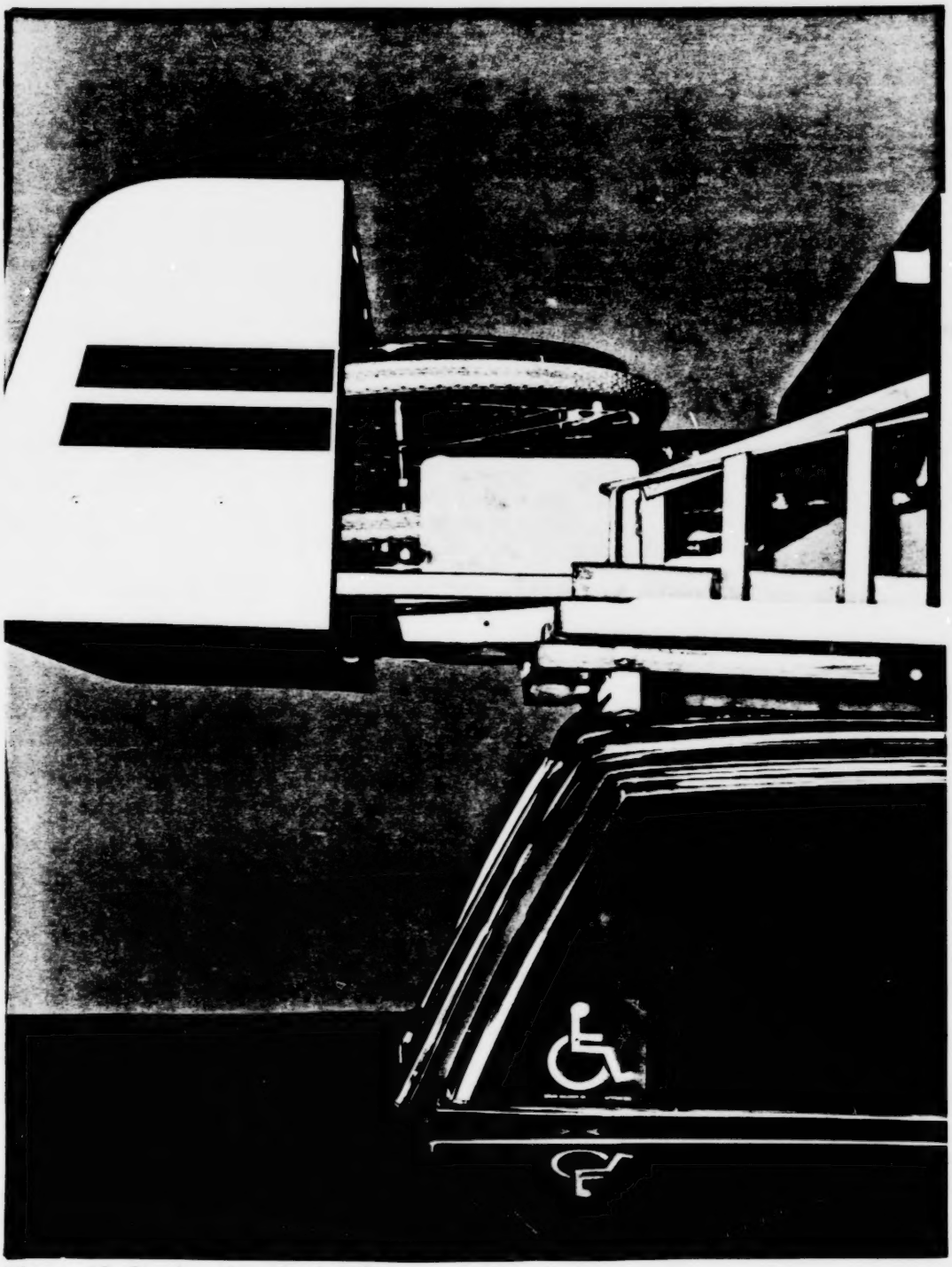

Figure 10 Storing the wheelchair

## 6. REAR BUMPER CARRIER

### 6.1 Description

The Tilt'n'Tote manufactured by Wheelchair Carrier Incorporated was selected to represent loaders designed to carry the chair on the rear bumper. The device was attached to a standard trailer hitch (replacing the towing ball) on the rear of a car. The wheelchair occupant must either be able to stand and walk short distances independently or must have an assistant to use this loader. For this description it is assumed that the wheelchair occupant loaded his own chair. She egressed the chair and unfolded the loader from its stored position on the bumper. A pin was pulled to release the loader from its upright position to its tilted position (figure 11). The wheelchair was folded and pushed onto the loader frame (figure 12) after which the entire assembly was tilted upwards to the horizontal (figure 13). The chair was then covered (figure 14). A bar and strap were then attached to secure the wheelchair to the base of the loader. Unloading involved the reversal of these steps. Figure 15 illustrates the combined activities of pulling the release pin and easing the chair down from horizontal for offloading.

### 6.2 Observations

Subject 1, 2, 3 and 4 participated in this test. All subjects had difficulty removing the pin which secured the loader in the horizontal position (figure 11 and 15). A force of 92 Newtons was required to remove this pin. During the unloading procedure it was necessary to pull out the pin and guide the chair to the ground. Because the removal of the pin required the use of two hands and a substantial tug by three subjects they were not able to use one hand to prevent the wheelchair from rolling off the back of the loader after it moved suddenly to its tilted position. The cover was awkward to handle and had a stiff zipper closing which subjects found aggravating although not impossible to use. The entire operation was very dirty. If loading and unloading were done in inclement weather the 3 1/2 minutes required by one subject (to unload the wheelchair) would have been unacceptable.

### 6.3 Advantages

1. Cost
   This loader could be purchased for under $300.
2. Cargo and Passenger Space
   No space inside the vehicle is required.
3. Parking Requirements
   The extra requirements for the loader and space for the person to maneuver was 124 cm.
4. Vehicle Requirements
   This loading device can be used with any vehicle fitted with a trailer hitch.

## 6.4 Disadvantages

1. Ease of Use
   The difficulty disengaging the release pin and balancing to lower the wheelchair would prevent many people from using this device. In addition users objected to the inconvenience and uncleanliness of donning and doffing the cover.
2. Speed of Operation
   Subjects who took as long as 3 1/2 minutes to unload the wheelchair complained that this would be inconvenient in bad weather.

## 6.5 Recommendations

This rear bumper carrier for wheelchairs would be useful for a person who uses a wheelchair for reasons of poor physical endurance. The only limitation would be the ability to pull the lever to disengage the tilt lock. Otherwise the device would only be useful if an able bodied person were always available to assist in loading and unloading the chair. Examples of the type of person are:

1. an elderly person whose spouse or other assistant was strong enough to operate the loader;
2. family or friends who wish to travel with a disabled person in their vehicle without sacrificing trunk space;

Figure 11 Pulling the release pin to change the loader to its tilted position

Figure 12 Loading the chair on the tilted loader

Figure 13 Pushing the chair to horizontal

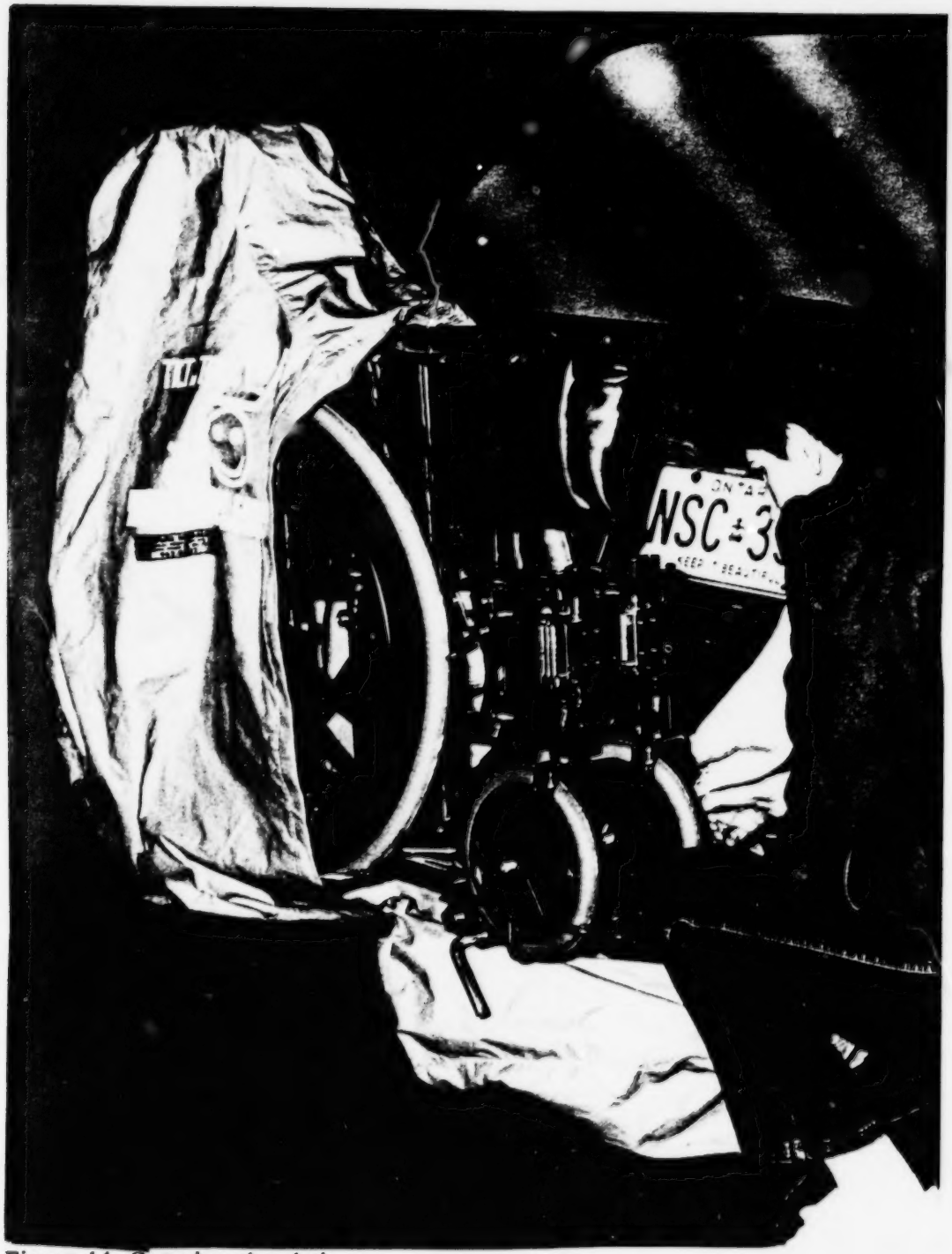


Figure 14 Covering the chair

Figure 15 Pulling the pin to lower the chair for offloading

# 7. MANUAL TRUNK LOADER

## 7.1 Description

The "E-Z Lift", manufactured by the Wheelchair Carrier Corporation is a device designed to assist in the manual loading of a folding wheelchair into the trunk of an automobile. The loader consists of two articulated metal arms joined at one end by a mounting frame attached to the trunk and at the other end by a handle and frame for the wheelchair. The person unlocked and lifted the lid of the trunk. The loader was unfolded from the trunk with one end positioned on the ground (figure 16). The wheelchair was folded and positioned in the frame (figure 17). After strapping the chair in place, the wheelchair and loader assembly was lifted by holding the handles of the loader (figure 18 and 19). The wheelchair was positioned inside the trunk (figure 20) and the trunk was closed. Unloading required the reversal of these steps.

## 7.2 Observations

Subjects 1, 2, 3 and 4 participated in the testing. Subject 1 had difficulty loading the chair and no other subject was able to accomplish the loading task. Subject 3 had difficulty unloading the chair while the other three subjects were unable to unload the wheelchair. The reason for the difficulty was that these subjects lacked the strength required to operate the loading device. In fact, one of the subjects injured her back during the unloading operation. Unloading the wheelchair using the loader required a peak force of 175 Newtons to be exerted when initially lifting the chair from the trunk. During this procedure the trunk is flexed forward creating a larger moment as compared to vertical lifting close to the body. Lifting the same wheelchair vertically with no lifting aid required 163 Newtons. The device provided some advantage to loading and unloading the chair during the phase when the chair was between the lip of the trunk and a few feet into the lowering operation. Whenever the wheelchair was closer to the ground the person had to stoop or crouch to reach the handles. This is a very unstable body position for an elderly or disabled person with poor strength, balance or coordination. An additional problem was that the loader scratched the body of the car in spite of the padding that we added for protection (figure 20).

## 7.3 Advantages

1. Cost
   The device sells for less that $300. and would therefore be affordable to most individuals.
2. Parking requirements
   No additional parking space is required.

## 7.4 Disadvantages

1. Ease of use
   The loader was very difficult to use, requiring the application of a force greater than was needed to lift the wheelchair alone. .
2. Cargo and Passenger Requirements
   Cargo space in the trunk must be relinquished if this loader were to be used.
3. Damage to vehicle
   The device scratched the bodywork of the car.

## 7.5 Recommendations

The loader has such limited application and because of its force requirements we do not recommend its use.

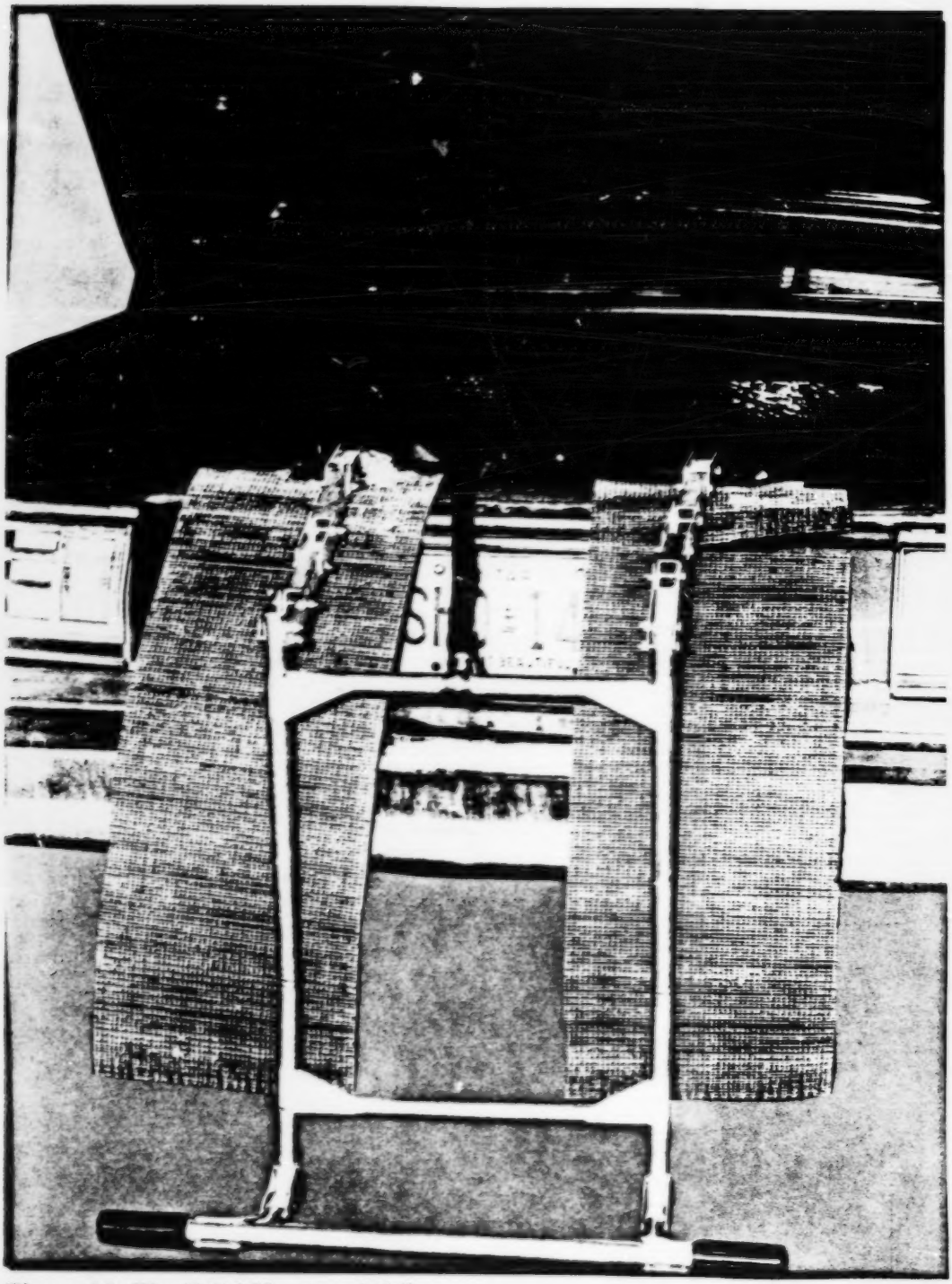

Figure 16 The E-Z Lift extended for use

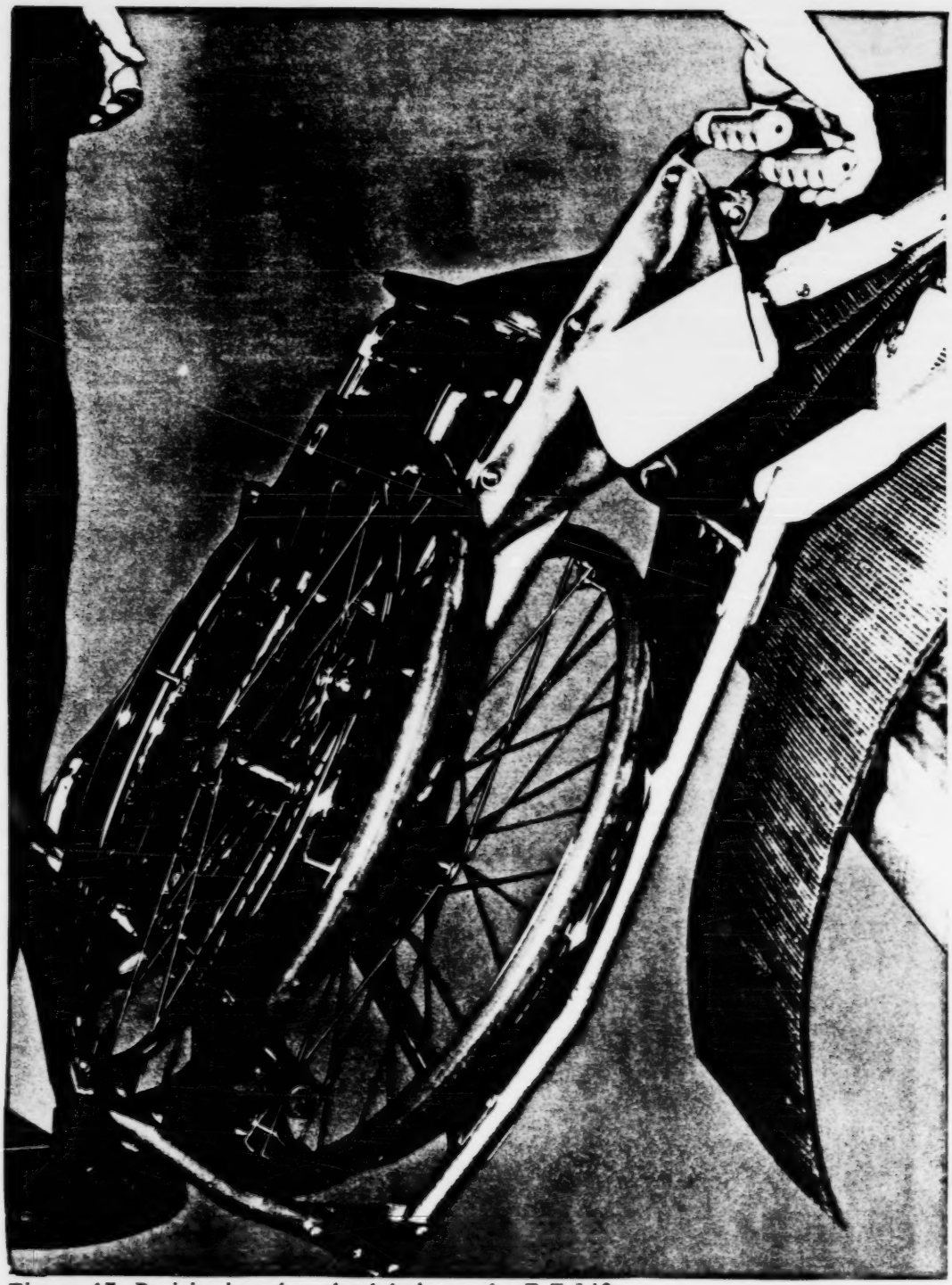

Figure 17 Positioning the wheelchair on the E-Z Lift

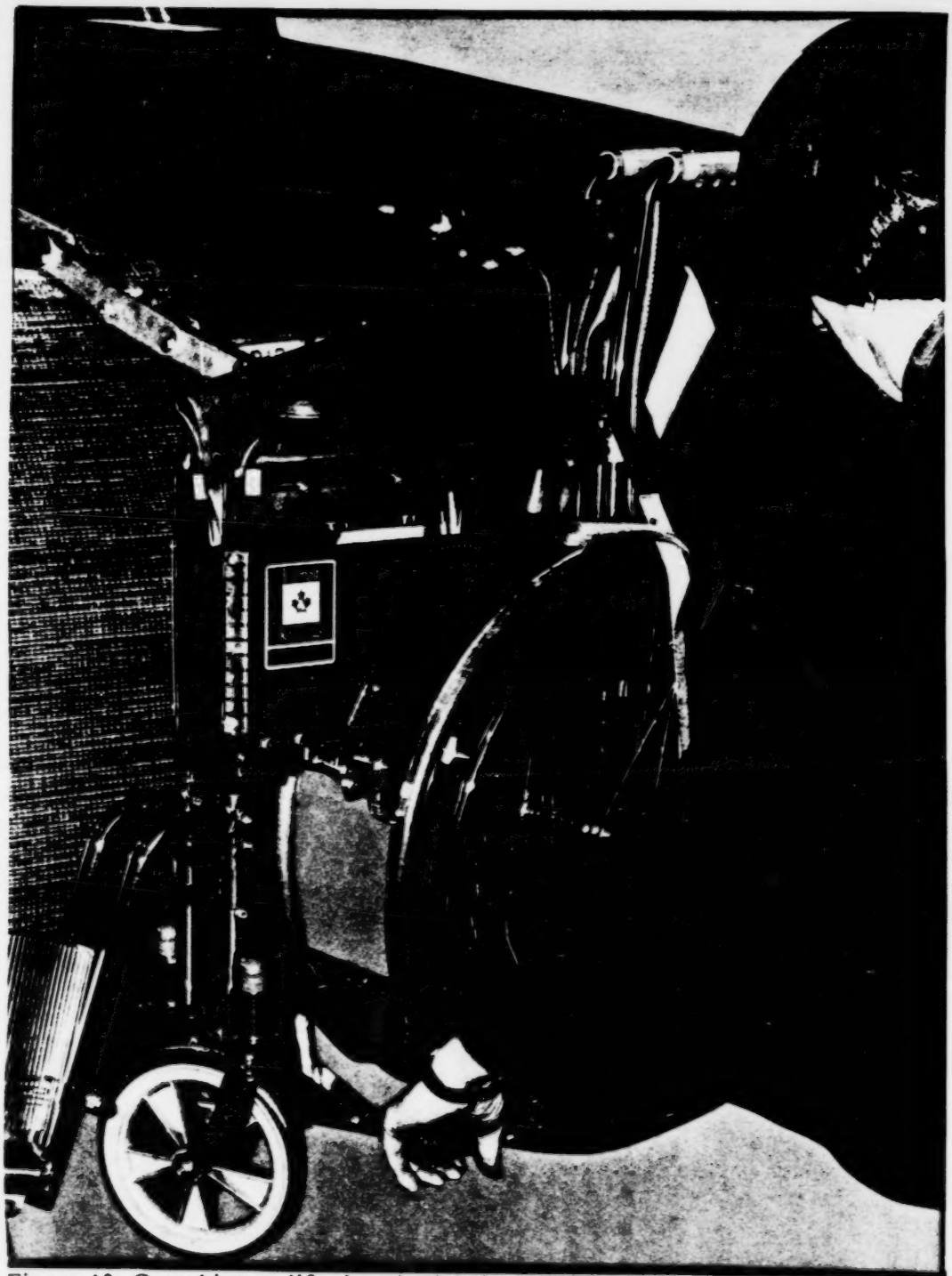

Figure 18 Crouching to lift the wheelchair up into the trunk

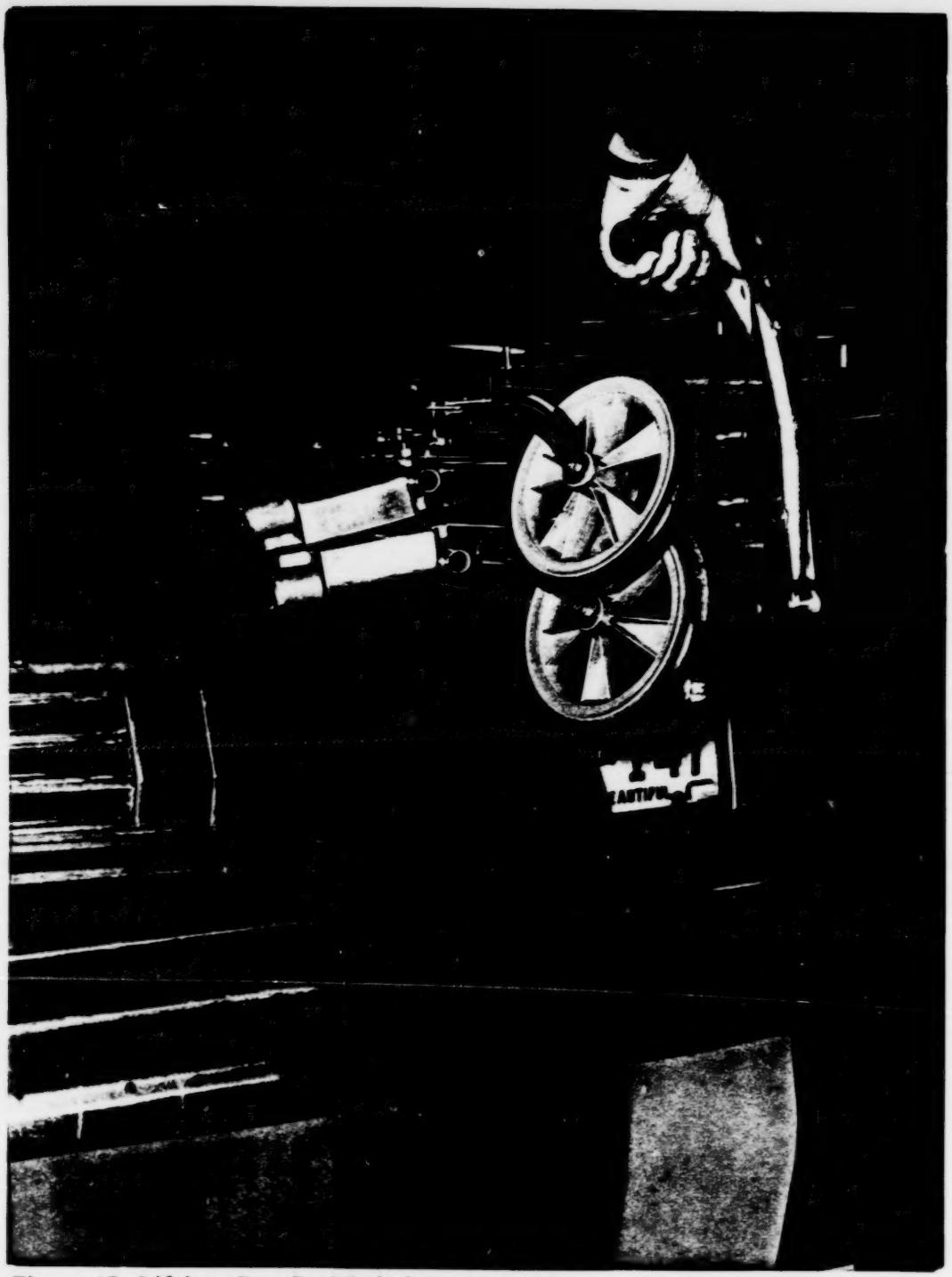

Figure 19 Lifting the wheelchair into the trunk

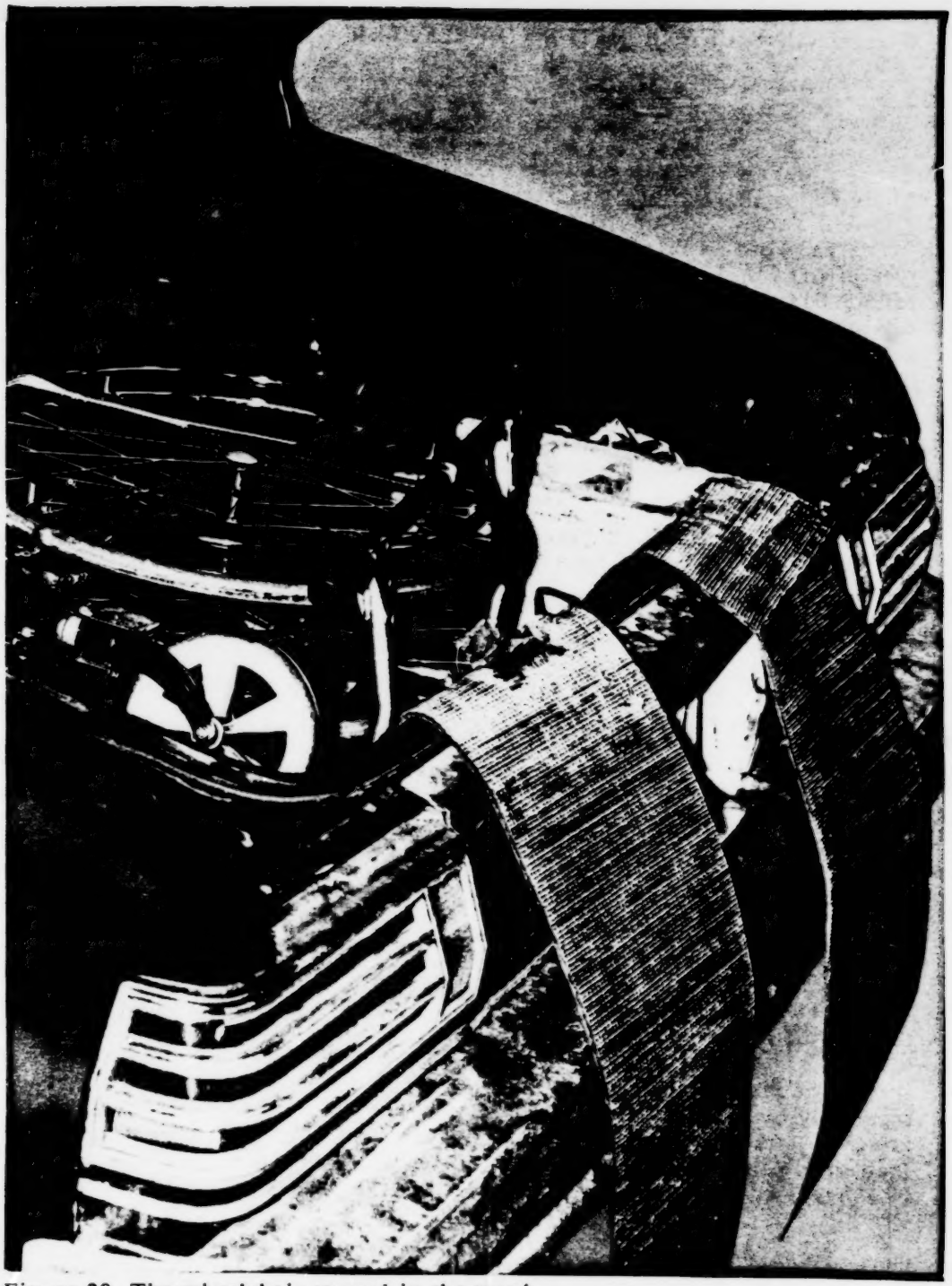

Figure 20 The wheelchair stowed in the trunk

## 8. TRUNK CRANE LIFTER FOR ELECTRIC SCOOTER

### 8.1 Description and Operation

The Fortress Scientific trunk crane lift was used to represent this type of lift for electric scooters. An extendable swivelling crane was mounted in the trunk of a minivan for this study. The crane could have been mounted in an automobile trunk. Power for the device came from the vehicle's 12 volt battery. To operate the loader the user stood up from the scooter and opened the door to the trunk. The crane arm was unhinged, raised and swivelled into place (figure 21). The seat and the batteries of the scooter were lifted manually from the scooter and placed aside. The handle bars were folded down. The nylon strap on the crane was extended and the docking hook was attached to the scooter base (figure 22). A rocker switch mounted in a control box was located and actuated to raise the scooter base. The base of the scooter was then manoeuvered into the minivan (figure 23) and lowered. The seat and batteries were separately, manually lifted into the van. The crane was detached from the scooter base and folded safely (figure 24) and then the door to the vehicle was closed. The logical reversal of these steps was used to unload the scooter.

### 8.2 Observations

Subjects 1, 2 and 3 participated in the testing. Subject 2 found it difficult to remove the seat from the scooter, subject 1 was unable to remove it and subject 3 had no difficulty removing the seat. The force required to remove the seat of the scooter was 199 Newtons. (Recall that vertical lifting of an Everest and Jennings Starliner wheelchair required 163 Newtons of force.) Subject 1 was able to lift the scooter seat if the back was separated from it (figure 25). All subjects found it too difficult to unload and reattach the scooter seat. Two problems contributed to the difficulty in removing the seat 1) there was a lot of friction in the connection between the scooter base and the seat and 2) the seat itself was heavy. Thus the problem was more a function of the design of the scooter than of the loading crane.

The manufacturer recommended that the batteries be removed and loaded separately by hand. All three subjects preferred leaving the batteries attached to the scooter so that they could be lifted by the crane rather than lifting them separately by hand (which required a force of 122 Newtons). All subjects found it easy to operate the crane.

### 8.3 Advantages

1. Parking requirements
   The use of this loader with space for the scooter requires a minimum of 61 cm. extra space behind the rear bumper.

2. Vehicle requirements

Many more vehicles can accommodate this scooter and lift than other lifts presently available. The dimensions of the trunk required to accommodate the scooter and crane are:

closed trunk:

| | |
|---|---|
| width | 118 cm |
| depth | 92 cm |
| height | 41 cm |

open trunk:

| | |
|---|---|
| width | 118 cm |
| depth | 92 cm |
| height | 96 cm (measured from floor to raised lid, 61 cm forward of the rear inside top) |

8.4 Disadvantages

1. Ease of Use
   In its present state the removal and transfer of the seat of the scooter is beyond the capabilities of many of the potential users.
2. Cost
   In addition to the cost of the scooter the lifting system costs approximately $700.
3. Cargo and Passenger Space
   The use of the trunk must be given up.
4. Speed of Operation
   Slightly less than five minutes was required by some of these subjects to load or unload the scooter. This was considered to be a long time to be standing in bad weather.

8.5 Recommendations

A user must be able to stand and walk from the rear of the vehicle to the driver's seat, otherwise an assistant would be required. It is recommended that an attachment be designed so that the seat of the scooter could be lifted using the crane. Alternatively the connection between the seat and scooter could be redesigned to reduce friction and the weight of the seat could be reduced to facilitate removal of the seat. If one of the options were accomplished the following persons could make good use of this device:

1. an elderly person, or a student, or a professional person, or a homemaker whose requirement for a scooter is related to poor endurance.
2. a couple, including an elderly couple, who have one able bodied member who can operate the loading device.

Figure 21 Accessing the crane lifter

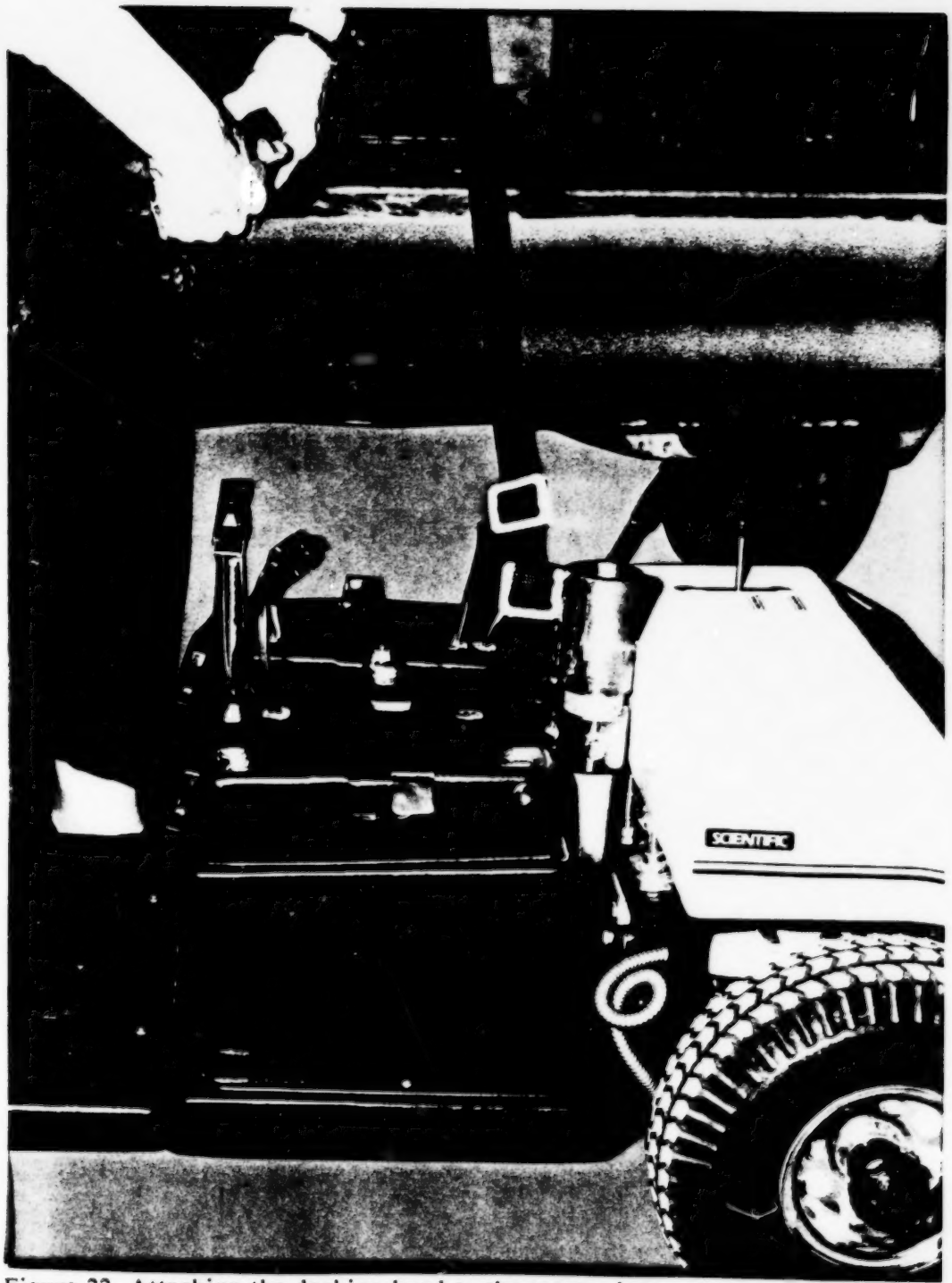


Figure 22 Attaching the docking hood to the scooter base

Figure 23 Maneuvering the scooter base into the van

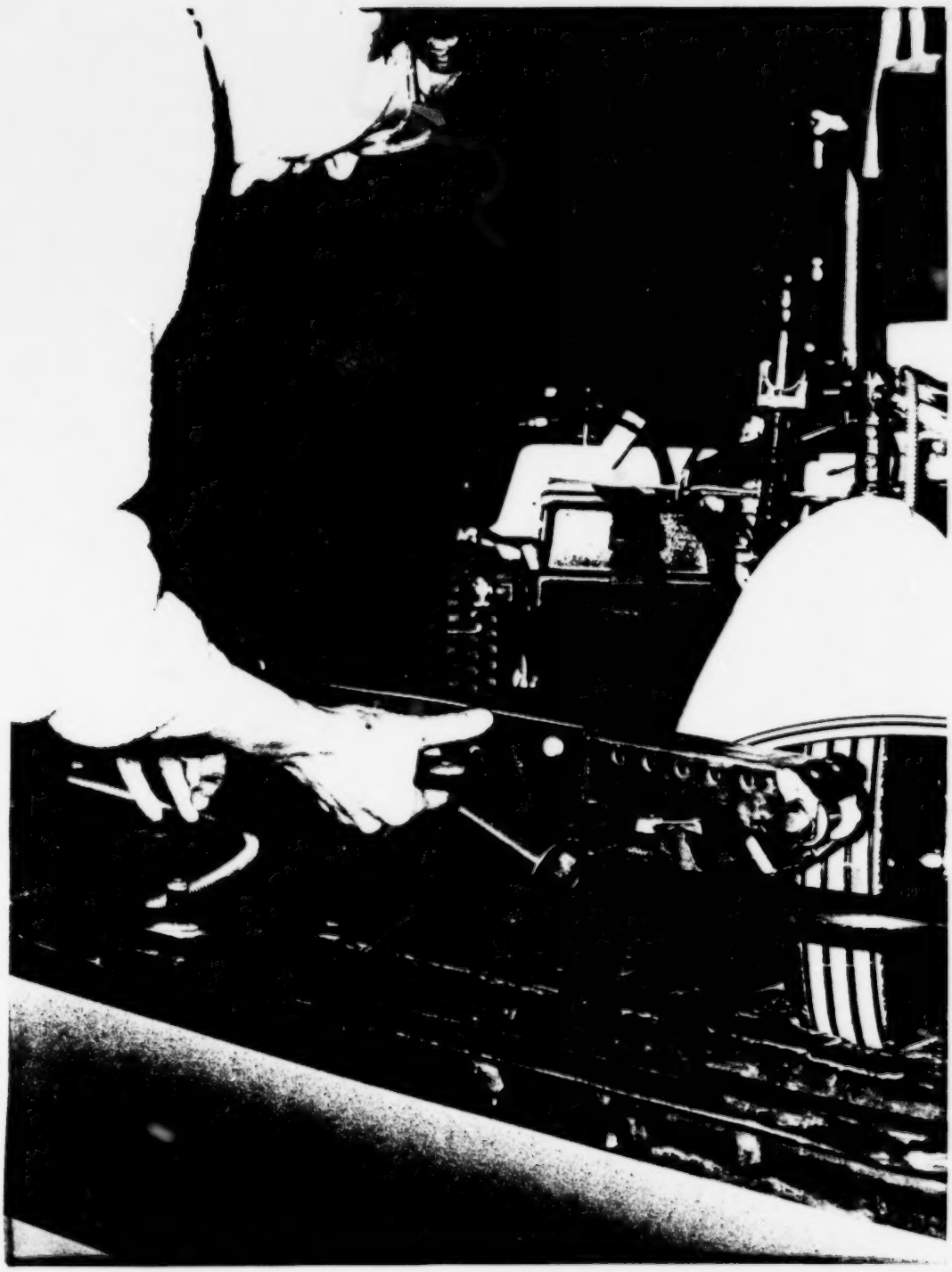

Figure 24 Stowing the crane

Figure 25 Removing the seat from the scooter

# 9 CONCLUSIONS

Five devices to load wheelchairs and scooters were assessed. Two of these, the cartop carrier and the back seat extension loader were found to be well designed. The remaining three loaders required improvements in design. Recommendations for changes are presented in the following chapter.

At the onset of this study we had identified the need for more information on devices to load wheelchairs into personal vehicles. This study reinforced the need to provide information to consumers, health care professionals and funding agencies. It is recommended that a guide for selection of loading devices be prepared. A proposal for the development of this guide is presented in the following chapter.

# 10 RECOMMENDATIONS

## 10.1 Recommendations for Improvements to Loaders

1. Rear bumper carrier

The operation of the release pin should be assessed and redesigned to reduce the forces required for operation. An alternative mounting bracket would be useful for vehicles which do not have a trailer hitch.

2. Manual trunk loader

The device requires complete redesign. The concept for the loader is good, however there are obvious problems which must be solved for this to be of any value.

3. Trunk Crane for the Electric Scooter

The main problem with this loader is the difficulty in loading the seat separately. This could be solved by investigating ways to make the seat easier to remove and by reducing its weight. The development of an attachment for the seat to facilitate using the crane to lift the seat would also help solve this problem.

## 10.2 Proposal for the Preparation of: a Guide to Wheelchair Loading Methods and Special Equipment

Wheelchairs and electric scooters help mobilize disabled and elderly people, but they have limited range. It is sometimes necessary to transport a wheelchair or scooter in a personal automobile to overcome this limitation. Many people encounter difficulties when trying to load their wheelchair or scooter into an automobile. In some cases training in how to load wheelchairs manually is all that is required. In other circumstances, a mechanical loading device is needed to solve the problem. The choice of method of loading chairs and scooters depends on the level of disability of the individual, the availability of assistance, the type of chair, the type of vehicle and a variety of lifestyle factors including financial, parking, passenger and cargo requirements. A guide to assist the selection of methods to transport wheelchairs will have a significant impact on the disabled and elderly population and will assist the function of health care professionals and funding agencies.

The objective is to produce an easy to understand manual which informs the wheelchair or scooter user about manual loading methods and loading devices that are available so that he can select the method most appropriate for his needs. The inclusion of manual loading techniques has been requested by both the disabled and elderly consumers and by a variety of health care specialists. These methods are not well known and their use might make the difference between mobility and immobility. In addition, biomechanically appropriate lifting techniques might prevent injury to those who feel that they do not require the use of a lifting device.

In several cases, more than one loader with similar but not identical characteristics exists. Although only one example of each generic type of loader would be presented in detail, information about similar loaders should be included so that the consumer can make his own choice.

The remaining tasks required to produce the guide are the listed below.

1. To gather information on prices, manufacturers, distributors, health care advisers, installers and technical details of the types of devices evaluated (including those similar but not identical to those in this study).
2. To develop a manual for manual loading techniques or loaders. The manual will include functional requirements, lifestyle factors and information regarding method of use, price, purchase and installation of the devices. A strategy will be developed so that a consumer can identify and prioritize his needs and limitations and match them with a loading method. Liberal use of photographs will assist the consumer in understanding how the loaders operate.

A black and white copy of the colour photo suggested for the cover of the manual appears in Figure 26. The manual will be written in a straight forward style which is clear and simple to understand. A resource book of this nature will be a practical guide for consumers, health care workers, funding agencies and installers of equipment.

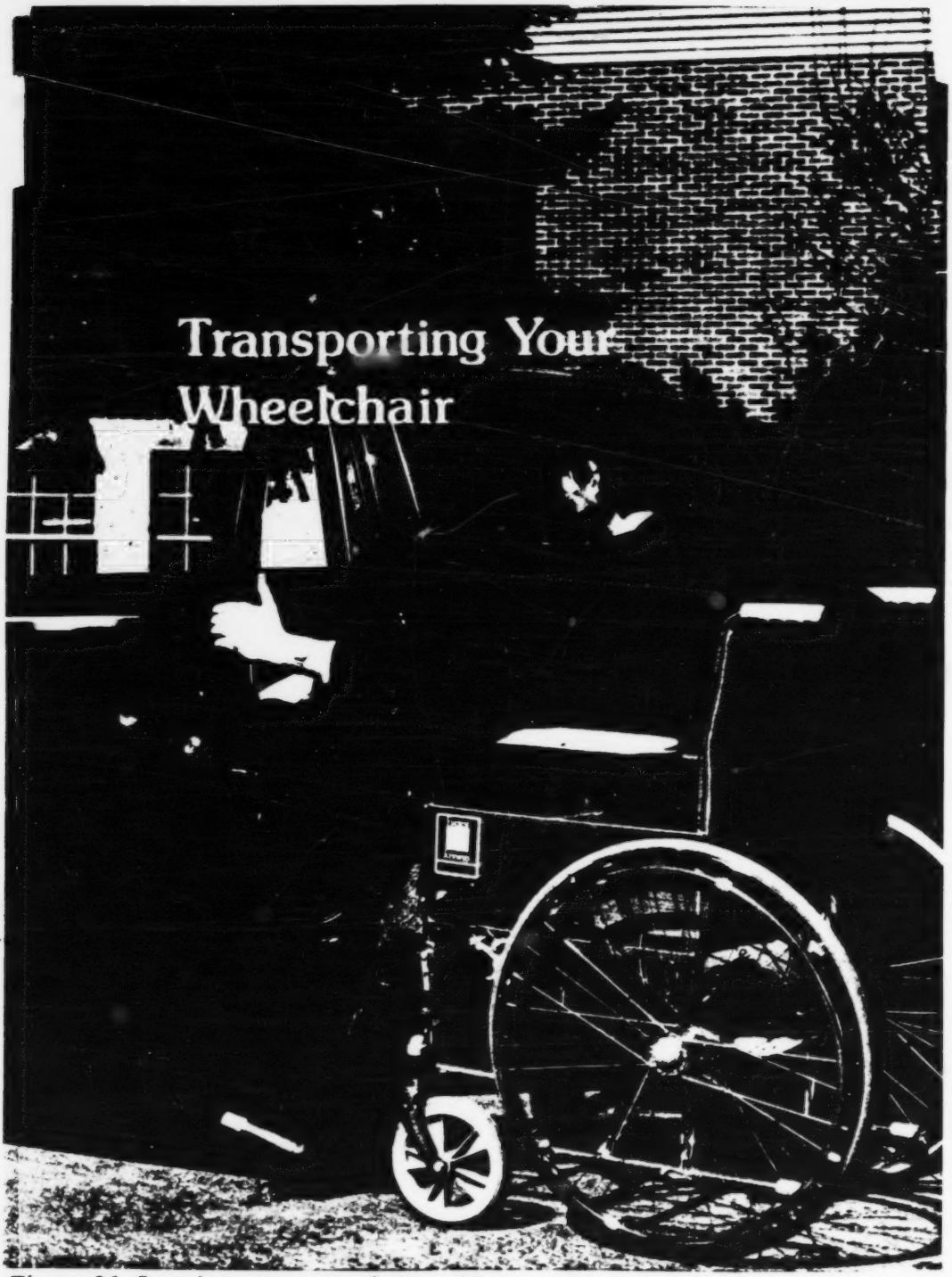


Figure 26 Sample cover page of the guide

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